THREE TRACTS

WRITTEN

By the Honourable

ROBERT BOYLE.

Of the { *Temperature of the Subterraneall.* / *Temperature of the Submarine.* / *Bottom of the Sea.* } Regions.

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ADVERTISEMENT.

THe two following Tracts were deſign'd to have been accompanied by three or four Others, whereof the Firſt, Treated about the Temperature of the Regions of the Air, as to Heat and Cold, and had been premiſed to the Two that now come forth, had it not been judged more proper to reſerve them to accompany ſome other Papers concerning the Air. To the following Tract about the Submarine Regions, it is thought fit to adjoyne ſome Relations about the Bottom of the Sea, to which was to have been added ſome Obſervations, concerning the Saltneſs of the Sea; but in that Treatiſe, ſome Blanks having been left for Particulars, which the Author could not feaſonably find among his Loos Papers to fill them up with, theſe that now appear, having no dependence on them, it was not thought fit they ſhould ſtay any longer for them.

But about theſe ſeverall Tracts, this Generall advertiſement is to be here given, That being Hiſtoricall Pieces, conſiſting chiefly, (though not only,) of ſuch Particulars, as the Author muſt owe to the Informations of Others, he would not ſtake his Reputation for the Truth of every one of them; contenting himſelf, to have performed what can be reaſonably expected of him; which is, that he ſhould carefully make his Inquiries from credible Perſons, who for the moſt part, deliver their Anſwer upon their own knowledge, and that he ſhould faithfully ſet down the accounts he procured from ſuch Relators.

Of the

TEMPERATURE

Of the

SUBTERRANEAL REGIONS,

As to *HEAT* and *COLD*.

OF THE TEMPERATURE, Of the SUBTERRANEALL REGIONS, *As to Heat and Cold.*

CHAP. I.

IF when I uſed to viſit mines, I had thought of writing on the ſubject I am now about to treat of, and had deſign'd to ſatisfie my ſelfe about the Temperature of the Subterraneall Air, as much as I did about the other Subjects I was then concern'd to be inform'd of, I think I ſhould have enabled my ſelfe to deliver much more upon my own obſervation, then I ſhall now pretend to doe. But though for the reaſon newly intimated, and becauſe of my being particularly ſubject to be offended by any thing that hinders a full freedom of Reſpiration, I was not ſolicitous to goe down into the deep mines; yet after having diſcourſ'd of the Temperature of the Air above Ground, I preſume it may not be improper or unwellcome to ſay ſomething of the Temperature of the Subterraneall Regionsand of

the Air reaching thither. For deep mines being places which very few have had the opportunity, and fewer have had the curiosity to visit, and of which I have scarce found any thing at all observable by Classick Authors, and by other writers, but very little, especially that I think probable enough to make use of, I presume it will not be unacceptable to you, if of Regions so little frequented, and less known, I report what I have been able to learn (by diligent enquiry purposely made) from the credible Relations of severall Eye-witnesses differing in nation, and for the most part unacquainted with each other.

Though I do not think it absurd to suspect that in some places of the Earth, the peculiar constitution of the Soil, and other circumstances, may make it reasonable to assign those places fewer or more Regions then three; yet speaking in the Generall, the Ternary number seems not inconvenient to be assigned to the Subterraneall Regions, not so much upon the score of the Analogy, that by this Division will be established between the Regions of the Earth and of the Air, as because there seems to be a reason of the Division included in the Division itself. And indeed Experience appears to favour it in the Subterraneall Cavity, that I have hitherto been able to procure an account of, from any Ocular witness, and (very few excepted) one of the deepest that we yet know of, in the world. And since it has been received for a Rule among Philosophers,

that

that which is perfectest or compleatest in its kind, ought to be the Standard whereby the rest are to be measured, or estimated, I shall begin the remaining part of this Essay by a Relation that I obtained from a Chymist, that had purposely travelled into Hungary, and other places to visit the mines those parts are justly famous for, and who bringing me the honour of a Complement from a Prince, to whom he belonged gave me the opportunity of asking him divers Questions, his Answers whereunto (which I presently after put into writing,) afforded me the ensuing account.

CHAP. II.

THat very near the Orifice of the Groove, he felt the Air yet warm; but afterwards descending towards the lower parts of the Groove, he felt it cold, till he came to such a depth, as he had scarce attained by a quarter of an hours descent, and that the Cold he felt during this time seem'd to him considerable, especially when a descending he had reached to a good depth.

That after he had passed that Cold Region, he began by degrees to come into a warmer one which increased in heat, as he went deeper and deeper. So that in the deeper veins he found the Workmen digging with only a slight garment over them; and the Subterraneal heat was much

greater, then that of the free Air on the top of the Groove, though it were then *Summer*.

[What is here mention'd of a cold region in the Earth, has been since confirmed to me by an ingenious Physitian, upon an observation made in another Hungarian mine (near a Town whose name I remember not) that was not of Gold, but Copper; and of much lesser deepnesse then that newly spoken of. For this Relator answer'd me that in going down, he felt a considerable degree of Cold. And when I ask'd whether he found the like in his Return upwards, he told me, he observ'd it then too. And when I further inquired after the extent of this cold Region, he replyed, that not expecting to be ask'd about such Circumstances, he had not taken particular notice of them: but thus much Information my Questions procur'd me, that he began to feel the above mention'd coldnesse when he could receive no more light at all by the mouth of the Groove, and that this cold Region lasted till he came somewhat near the bottom, which was estimated to be about an 100 fathom or more distant (in a strait Line) from the Top.]

This Relation agrees well enough for the main, with that short, but considerable one of *Morinus*, (which I elsewhere cite) who above forty five years agoe, visited the deep Hungarian-mines in the month of July, and takes notice, that when he came down to the burrows, as he calls them, he did not find any heat, as at the mouth of the Well;

Well; but the beginning of a very Cold, as well as considerably thick Region: though I easily beleive him, when he confesses, that he felt it much the Colder, because he had left of his own Clothes, and put on the slight Garments used there by the Diggers. He further informs his Reader, that when they had descended about 80 fathoms beneath the surface of the Earth, he began to feel a breath of an almost luke-warm air; which warmth increased upon him, as he descended lower, pleasing him not a little, because it freed him from the troublesome scents of his former coldnesse. Adding that the Overseer of the mine who conducted him, affirmed to him, as also the Officers of other Hungarian mines unanimously did, that in all their mines, at least all the deep ones, after a thick tract of Cold Earth, there succeeds a Lower Region, that is alwaies hot. And that after they arriv'd at such a depth, they felt not any more Cold, but alwaies Heat, how deep soever they digg. And to add upon the by, though this Learned Man lay much weight upon *Antiperistasis*; yet in the next page to those that contain what I have been just now relating, he either very candidly or inconsiderately takes notice, that they inform'd him, that their mines, whether more or lesse deep, they observed that at some times in the year, a somewhat intenser heat was felt, and the two Times that he expressly names, are those oppositely qualified Seasons of *Summer* and *Winter*.

Having laid down these generall narratives, I now proceed to consider the Earths Regions in particular, about which the Summe of what I yet have to propound, may be conveniently enough compriz'd in the 4 following Propositions.

CHAP. III.

Proposition the 1.

THe First Region of the Earth is very variable, both as to Bounds, and as to Temperature.

The former part of this observation will not be difficult to prove, since 'twill be easily granted, that the manifest operation of the *Sun-Beams* is (*cæteris paribus*) greater, and reaches further in hot Climates then in Cold ones; in the midst of *Summer*, then in the depth of *Winter*.

The Second part of the Observation may be proved by the same Arguments as the First; to which may be added, as to some places, the Solidity or porousnes of the Earth, as also the nature of some Salts, Marchasites, and other Bodies contained in it, which by their natural Temperature may dispose the Soil to Coldnes or Heat. As I shall have occasion to shew, when I come to speak of the second Region.

In the mean time I have this to observe further, That in this First Region, the Air is usually more temperate, as to Cold and Heat, then that above

above the surface of the Earth, and that this Region is not wont to be considerably deep: Both parts of which Observation are capable of being made good by the same Reasons, and therefore I shall endeavour to prove them jointly.

That in the uppermost Region of the Earth, it should be less cold then above the surface, seems reasonable to be allowed upon this Consideration, That the *Subterraneall Cavities* of the Earth are sheltered by the thickness of the sides, from the direct action of the *S*un-Beams, the Winds, &c. and is also kept from an immediate, or at least from so full a contact of the externall Air, when that is vehemently, either heated or refrigerated.

And first as to the heat of the Sun, that That does much less powerfully affect such places as are sheltered from its action by solid Bodies, may appear by the Conservatories of Ice and Snow, wherein frozen water is kept in that State during all the Heat of *Summer*, and that oftentimes in Cavities that are at no considerable depth beneath the Superficies of the Earth. Nay I remember that having had occasion, (for the perfecting of some Conclusions I was trying) to keep Ice many weeks after the frosty Weather was gone, and a milder Season was come in, I was able to doe it, (contrary to the expectation of some Curious men,) without either digging to a notable depth in the ground, or building any substantiall *Structure* over the Cavity. For wanting

ting conveniencies, I contented my selfe (though 'twere in a champain place) with a pit somewhat broad at the bottom, of about four foot deep or lesse, whose mouth was shelter'd only by a little low thatch'd hovell, that was wide open to the *North*, and only skreen'd the mouth or vent of the little pit from the direct Beams of the *Sun*. And though I will not deny, that in deep Conservatories of *Snow*, the naturall Coldnesse of the Earth, especially in some places, may contribute to the effect; yet I remember, that discoursing once with a Traveller and Schollar that was born in hot Countries, of a conjecture of mine that in an arch'd building, whose walls were sufficiently thick, and whose Air were carefully kept from all avoidable intercourse with the externall Air, one may without digging so much as a mans depth into the Ground, make a sufficient Conservatory for Ice in very open and unshelter'd places, and even such as *Salisbury plain* it selfe; discoursing (as I began to say) with this Traveller about this Conjecture, he told me, that at a place he nam'd to me, in the Southern part of *France*, whose heat seem'd to me to exceed that of divers parts of *Italy*, some Curious persons that were resolv'd at any rate, to have Ice in *Summer*, though the *Soil* were such, that they could not dig 4 foot without meeting with water, were yet able to make use of Conservatories by covering the Brick-Building they made over their pits, with *Clay* and *Sand* to a very considerable thickneſſe

thickneſſe, and taking care that the only place that ſhould permit acceſſe to the outward Air, ſhould be a ſmall Northern Door to go in and out at, fitted to ſhut exactly cloſe, and fenc'd with a little porch furniſhed with another Door. And by this means he affirms theſe Gentlemen to reſerve the included Ice not only all the *Summer* long, bnt ſometimes for two or three years together, the heat of that Region making many of their Winters too mild to recruit them with Ice.

To all theſe things I ſhall add, that even where the intercourſe is not quite debarr'd, but left free enough betwixt the Subterraneall and the ſuperior Air, the operation of the Sun-Beams may be very much leſſe in a Cavity though but ſhallow, beneath the Surface of the Ground then above it. For beſides that Tryalls have inform'd me, that Liquors that differ in little elſe then in conſiſtence, will not ſo eaſily pervade each other, as a man would ſurmiſe; unleſſe ſome externall motion haſten their intimate mingling with one another. I remember that one morning pretty late, having had the Curioſity to deſcend into a pit where they were digging out Iron Oar; though this Cavity had no very narrow Orifice, and was dugg directly downwards, and exceeded not ten or twelve foot in depth: yet I found not the heat at all troubleſome whilſt I ſtaid there, Though the pit were in an open feild unſhaded by Trees, and though the Air abroad were much

heated

heated at that time of the year, which was in that ſeaſon (or at leaſt very near it) that is wont to be call'd the Dogg-Daies.

CHAP. *IIII.*

AND as we have ſhewn, that the Subterraneal Air, even in the firſt Region is uſually much leſs heated, then the *Superterreſtriall Air*; ſo we may alſo eaſily obſerve, that That Inferior Air is (*Cæteris paribus*) wont to be much leſs refrigerated by the grand Efficients of intenſe Cold, then the *Superior Air*.

I will not urge on this occaſion what I have obſerved by a ſurer way, then for ought I know has been before practiſed, about the ſmoaking of ſome *Springs* in *Froſty Weather*; becauſe I doe not know but that thoſe *Springs* may have come from, or paſſed a good way through, ſome place very deep beneath the Surface of the directly incumbent ground, and perhaps from a Soil peculiarly fitted to warm them: whence the water may have deriv'd a warmth conſiderable enough not to be quite loſt, till it began to ſpring out of the ground, where it needed only not to be quite Cold to appear to ſmoke; the intenſe Coldneſs of the Air making thoſe exhalations viſible in *Froſty Weather*, which would not be ſo in milder: As is evident in a mans Breath, which appears like a ſmoak in *ſuch weather*, though it be not viſible in *Summer*.

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That therefore, which I ſhall propoſe in favour of our obſervation, is firſt taken from the nature of the thing, which may perſwade us, that the *Subterraneall Air* being though comparatively cool, yet indeed moderately warm in *Summer*, ought not to be affected with Winters Cold, ſo much as that contiguous to the *Surface* of the Earth, from whoſe immediate Contact, it is by a thick arch of Earth (if I may ſo call it) defended; and that the Cold reigns moſt in the free Air; and the *Superficiall* parts of the Terreſtriall Globe, may appear by Waters beginning to freeze at the Top, not at the Bottom. To which Reaſon from the nature of the thing, I ſhall add only this from experience, that we ſee that in Cellars that are arch'd and carefully kept cloſe from the Communication of the outward Air, Beer, and other Liquors may be kept from freezing in froſty, and ſnowy Weather. As I have obſerved in a cellar that was but ſhallow, but well arch'd in a *Winter* that was ſharp to a wonder, and froze ſtronger Liquors then Beer in another Cellar very near it, that differed not much from it in depth, but had not ſo thick and ſolid a roof. And that not only here in *England*, where the Cold is leſs violent, but even in *Ruſſia* it ſelfe, where it is wont to be ſo extream, it reaches not near ſo deep as one would think, I learn'd by Inquiry purpoſely made of an ingenious Phyſitian that lived at *Moſco*, who anſwered me, that others and he himſelfe, did in that City keep all

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the Winter long, not only their Wine but their Beer from freezing in Cellars that were not above 12 or 14 foot deep, but well cover'd above, and carefully Lin'd with plankes of Firr, without any entrance, but a ſmall trap-Door (commonly at the top,) which was fitted ſo exactly to the Orifice it was to cloſe, as to exclude (as much as was poſſible) all communication between the internall and externall Air, that the latter might not affect the former with it's Coldneſſe.

I have indeed ſuſpected that in ſome Cellars, the comparative warmth we find there, may be partly due to Subterraneall Exhalations that are pent up in them: and perhaps too in ſome meaſure from the Steams of the fermenting, or fermented Liquors lodg'd in thoſe places. And I was ſomewhat confirmed in this Suſpition, by an Information my Inquiries obtained from the newly mentioned Doctor, who told me upon his own obſervation, that in one of the Cellars he made uſe of at *Moſco*, having occaſion to open the above mentioned trap-door, after the Cellar had for a good while been kept very cloſe ſhut, there came out at the vent that was thereby given, a copious Steam in the forme of ſmoak, which to them, who had their Bodies affected with the externall Air, was very ſenſibly warm, and was almoſt unfit for Reſpiration. Which Circumſtance increaſed my ſuſpition that there might be among theſe ſteames, ſome of the nature of thoſe,

that

that have been obſerved to come from fermenting Liquors, eſpecially Wine, and ſo abound in ſome Cellars, as almoſt to ſtiffle thoſe that ventured into thoſe Vaults, And to kill ſome of them outright. Which effects the long abode of Subterraneall *Steams* in ſtagnating Air, even in many places, where no metalline Oars at all, nor other noxious mineralls have been found, has enabled that Air to produce. Of which divers ſad Inſtances have beengiven within leſſe then a mile of this place, upon mens firſt going down into pitts or Wells, that had not in a long time been open'd or made uſe of: (but this is here mentioned only upon the By) nor have we any neceſſity to fly to *Subterraneall Exhalations*, for the Comparative warmth that good Cellars in generall afford in froſty weather; ſince that *Phænomenon* may be accounted for, by the reaſon formerly given, That the cloſeneſſe of the Cavity, and the thickneſſe of the ſides and Roofe, keep it from being vehemently affected with the Cold of the Ambient Air.

I know 'tis pretended that the warmth we ſpeak of, proceeds from an *Antiperiſtaſis*, but not now to engage in a controverſy that would take up too much time, it may here ſuffice to repreſent, that in our caſe there appears no neceſſity of recurring to it, the *Phænomenon* being ſolvable by the Region newly cited; which may be confirmed by this Experiment, that in the Vaulted Cellar above mention'd, wherein Beer was kept from freezing,

in

in an almost prodigiously sharp Winter, the included Air, though sensibly warm, to those that came out of the free Air, had not so intended its native heat, as the Assertors of *Antiperistasis* would have expected; being Colder then the free Air commonly is in that place, not only in the heat of *Summer*, but in other seasons, when the weather is Temperate; As I was assur'd by comparing my own observations made at other times, with the account brought me by a skil lfull person, whom I employ'd into that Cellar at late hours, in one or two of the sharpest nights of the forementioned cruell winter with the same excellent seal'd weather-glass that I had long kept suspended within a stones cast of that place.

CHAP. V.

HAving said thus much about the Earths uppermost Region, I now proceed to that which lies next beneath it; whose Temperature I cannot so conveniently give an account of, in less then two Propositions, whereof the First is this;

Proposition the first.

The Second Region of the Earth seems to be for the most part cold in comparison of the other two.

This proposition may be confirmed partly by Reason, and partly by experience.

And

And first it seems consonant to Reason, that since the Earth is naturally a Bodie consisting of gross and heavy parts, that are *usually* much lesse agitated, then those of our Organs of Feeling, it should as to sense be cold; and that therefore that quality may be justly ascribed to it, in that Region where by vertue of its situation, it is kept from being considerably affected, either by the heat of the Superior Air, or by that of the deep parts of the Earth: which upper, and lower heat are the two Agents, that seem of all others the most likely to put its parts into an unusuall motion, and thereby change its naturall Temper.

That our proposition is also confirmable by Experience, may be gathered from the *Relations* set down in the former part of this discourse.

And here it will be proper to take notice of the Advertisement intimated in the close of our above delivered proposition, That this Coldnesse ascrib'd to the second Region of the Earth, is to be understood comparatively to the other two. For otherwise that even this Earth is not (as many naturallists would have it) the *Summum Frigidum* I gather from this, That I could never hear of any Ice met with there, at any time of the year though *Snow* or *Hail* may be produced in the middle Region at differing, and sometimes quite opposite seasons of the year; nay, I have not found by the Answers that were made me by those that have descended far enough into this Region, that they found the cold any where very great, or that

in some places they have found it at all considerable. As we shall see in the explication of the next proposition. I know not whether it will much strengthen what has been said, if I add, that I learned by inquiry of such persons as I lately mentioned, that at the mouth of deep Grooves, in mines, the steams that ascend, do often feel warm; though the outward Air where the Observation is made, be affected with the heat of *Summer*. But *though* this *probably* argue, that if the middle Region of the Earth, through which these Steams must ascend, were very intensely co'd, they would be so refrigerated in their passage, as to feel rather Cold then hot at their appearing above ground, especially in Summer: yet I shall not lay much weight (for some may perhaps be allowed it) upon this Argument; because I have not yet tryed, how far a warm Steam may be alter'd in its passage, thorow a Cold Conduit: not to mention that in the Earth, the passage by being directly upwards may be much the nimblier traversed.

CHAP. 6.

THe second proposition relating to the Temperature of the second Region of the Earth, may be delivered in these Terms.

Proposition the 3.

In severall places, which by reason of their distance

stance from the surface of the Earth, one would refer to the middle Region of it, The Temperature of the Air is very differing at the same times of the year

I chose to express my selfe thus, to prevent some ambiguities and objections which I foresaw, that shorter, but less clear and full expressions, might give occasion to.

In the proofe of our proposition, both Experience and Reason may distinctly be employed. And to begin with experience,

Whereas in the above recited descent into the *Hungarian-Mines*, there was observed a notably Cold Region of a considerable thickness, I have purposely procured accounts from divers persons that have here in *England* had occasion, some of them frequently to descend into deep pits or Grooves of differing mineralls, without finding by the narratives they made me, that they took notice of any notably cold part that they passed thorow; unless I particularly asked a question about such a thing. But for ought I could gather from their Spontaneous Relations, they felt in *Summer-time* a remission of the heat of the externall Air, assoon as ever they began to descend; which warmth did not so far decrease, as to terminate in any notable Coldness, before they came into a deeper part of the Earth, where they are never troubled with that quality. And some of these Relations I had from professed Miners, and was curious that the Relations I procured should

be of *Subterraneall parts* seated in very differing parts of *England*, as well as of places not all, or most of them having Veins of one and the same minerall. And I learned by particlar inquiry from a practicall Mathematician that was often employed about Lead-mines that at such depths as, (according to *Morinus*) the second Region of the Earth reaches to, he himselfe observed it to be sensibly warm at all seasons of the year (for about that Circumstance I was peculiarly solicitous to be satisfied.)

Nor is it unconsonant to Reason, that the middle Region of the Earth, in the sense meant in the proposition, should not be of the same temperature in all places; not only because of the differences, which the Climate may produce, by reason of its being very much hotter, or very much colder in one place then in another; but from the peculiar constitution of the *Soil*; to the Consideration whereof I shall here confine my selfe.

Now this Temperament of the Soil it selfe may be divertified, not only by its greater or lesser compactnesse (upon which account some *Soils* are Rocky or stony and others Light and spongy) but from the nature of the springs of Subterraneous Liquors, that may abound in it, or strain through it into the Groove or pit, we suppose the Observer to be in; and that especially by the mineralls, particularly Salts, and Marchasites that grow near the sides of the Well, or are brought thither by the waters.

To

To illustrate this, give me leave to consider, that nature dos not regulate her selfe under ground by our imaginary Divisions: but, without taking notice of them, produces marchasites, Salts, and other mineralls, most frequently (perhaps) in what we call the lower Region of the Earth; but yet sometimes to, in our upper Region and oftentimes in our middlemost Region. Let us then suppose, that in some places of this last nam'd Region, there be a mine of that Earth that naturally abounds with embryonated nitre, or with some other salt that is apt, especially being dissolv'd or moistened with water, (a thing very familiarly to be met with in mines; to send out a refrigerating Effluvium, or by its contact to cool the Air. Let us also suppose that by the sides of another Well of the same depth, there are store of unripe mineralls that are in the process of generation, or rather a great quantity of marchasiticall Earth, if I may so call it, that is such a substance, as I have met with, in more then one place, copiously impregnated and as it were blended with mineralls of a marchasiticall nature; and yet of so open and loose a Texture, as not only water would in a few hours, but Air also would in not very many, evidently worke upon it. And since during the time that marchasites are slowly dissolving, it has been observed according to what we have elsewhere delivered * that many

* *The Tract here pointed at is a Discourse of Subterraneall Fire and Heat.*

many of them will conceive a very considerable degree of heat, will it not be very ptobable, that the Temperature of the Earth in the place that abounds with these Marchasiticall mineralls will be very warm in comparison of the Temperature of the other place, where the Soil dos plentifully produce nitrous, and other refrigerating Bodies; though both the places be supposed to be at the same distance from the surface of the Earth, and consequently in the same Subterraneous Region.

Upon the like grounds, it may also be suspected, that in the same places the Temperature may not be alwaies the same, even upon the account of the Soil. For I elsewhere shew, that some Saline Earths, especially nitrous, and some mineralls that partake of the nature of marchasites, admit a kind of graduall maturation, and perhaps other Changes that seem to be spontaneous. And that such changes happen the more notably in those parts of such Bodies that are exposed to the Air, as those are that chance to be placed at the sides of the deep Wells we are talking of. Which things being presupposed, 'twill not be absurd to conceive, that the minerall, to which either heat or cold is to be referr'd, may be more copious, ripe, and operative at one time, then at another; or that at length, all the Earth capable of being, as it were Assimilated by the minerall rudiments harbour'd in it, may be consumed, or the minerall it selfe may artive at a perfection

of

of maturity, which will make its texture so close as to be unfit to be penetrated, and wrought upon, as before, by the water or other Liquor that occasioned its incalescence.

CHAP VII

I Omit to speak of the transient changes that may be occasion'd in the temperature of the second Region of the Earth by severall Accidents, and especially by the Subterraneall Exhalations, that in some places and times copiously ascend out of the lower Regions of the Earth. Nor shall I insist upon any of the other causes of a more durable difference of temper in some parts of the second Region, such as may be the Vicinity of Subterraneall Fires in the third Region that heat the incumbent *Soil*; because I would hasten to the Third and last part of this Discourse: which yet I must not do without premising this advertisement, that I think my selfe oblig'd to speak the more hesitantly and diffidently about the Temperature of Subterraneall Air; because mineralists have not had the Curiosity to examine it by Weather-glasses, which would give us much more trusty Informations then our sense of feeling powerfully preaffected by the cold or heat of the externall Air. I did indeed send fitt Instruments to some daies journey from this place, to examine the Air at the bottom of some of our

deep mines: but through some unlucky casualties upon the place, the attempt miscarried. But when I shall (God assisting) recover an opportunity that I have since wanted, I hope an accurate *seal'd Weather-glasse*, join'd with a portable Baroscope will give me better Information then mineralists have yet done. I say a seal'd Weather-glasse because though common Thermoscopes had been employed by miners, I durst not rely upon them; being perswaded by tryalls purposely made, as well as by the Reason of the thing, of the Fallaciousnesse of such Thermoscopes: for in them the included Air is liable to be wrought upon, not only by the Heat and coldnesse, but by the weight or Pressure of the externall Air. So that if a Thermoscope be let down from a very considerable height, at the top of which the station of the pendulous Liquor be well markt, that Liquor will be found to have risen, when the Instrument rests at the bottom, as if the included Air were manifestly refrigerated: though the temper of the externall Air may be in both places alike, the cause of the pendulous Liquors rising being indeed that the Aereall pillar incumbent on the stagnant Liquor, is higher and heavier at the bottom, where the Instrument rests, then that which lean'd upon it, at its first or upper station nearer the top of the Atmospher. From whence 'twill be easy to conclude that at the bottom of a deep Groove, where the Atmosphericall pillar that presses the stagnant water

water will be much longer and heavier then at the top, the Air may appear by the Instrument to be colder in places, where 'tis really much hotter, the increased weight of the incumbent Air being more forcible to impell up the pendulous Liquor then the indeavour of expansion procur'd in the included Air by the warmth of the place is to depresse it.

CHAP. VIII.

THat which challenges the third and last part of my discourse, is the lowermost Region of the Earth, about whose temperature I shall comprize, what I have to say in the following Proposition.

Proposition the 4.

The third Region of the Earth has been observ'd to be constantly and sensibly warm, but not uniformly so; being in some places considerably hot.

I mention that the recited temperature has been observed in the Lower Region, because I would intimate, that I would have the proposition understood with this Limitation, as far as has been yet (that I know of,) observed. For allmost all the deep Grooves that mineralists have given us accounts of, and wherein men have wrought long enough to take sufficient notice of the

the Temperature of the Air, have been made in Soils furniſhed with metalline Oars, or other mineralls, without which, men would not be invited to be at ſo great a charge, as that of ſinking ſo very deep pits, and maintaining work-men in them. So that experience has yet but ſlenderly, or at leaſt not ſufficiently informed us of the Temperature of thoſe parts of the third Region of the Earth, that are not furniſhed with ponderous mineralls, and conſequently has not informed us of the Temperature of the Lowermoſt Region in generall; as will better appear by what I ſhall ere long repreſent.

Having premiſed this Advertiſement about our propoſition, we may proceed to the diſtinct prooſe of the two parts or members it conſiſts of.

And to begin with the firſt, whatever the Peripateticks teach of the innate Coldneſſe of the Earth, eſpecially where 'tis remoteſt from the mixture of the other Elements; yet having purpoſely inquired of ſeverall perſons that viſited and alſo frequented the Third Region in differing Countries, Soils, and at differing depths under ground, and Seaſons of the year, I did not perceive that any of them, had ever found it ſenſibly and troubleſome cold in the Third Region of the Earth. And on this occaſion I remember I had ſome light ſuſpition, that, (at leaſt in ſome Caſes) the narrowneſs of the Cavities wherein the Diggers were in divers places reduc'd to worke, might make

make the warmth they felt, proceed in great part from the Steams of their own Bodies, and perhaps of the mineralls, and from the Difficulty of cooling or ventilating the Blood in an Air clogg'd with ſteams. And I was the rather induced to thinke this poſſible, becauſe I had (even in metalline mines that were but ſhallow and very freely acceſſible to the Air) obſerved a ſtrong ſmell of the metall abounding there.

I have likewiſe found by ſeverall tryalls, that the exhalations that proceed from the Bodies of Animalls, doe ſo vitiate the Air they abound in, as to make it much leſs fit for their Reſpiration, and to be apt to make them ſick and faint. Wherefore I thought it not altogether unfit to inquire, whether the heat of the Subterraneall air, in ſuch places as have been newly mentioned, might not be referr'd to theſe Cauſes? But I was anſwered in the negative; eſpecially by an inquiſitive perſon that had been in the deepeſt and hotteſt mines that have been viſited by any Acquaintances of mine.

This way of accounting for the Subterraneall Warmth being laid aſide, it ſeem'd I confeſſe ſomewhat difficult to conceive how it ſhould be produced; yet two principall Cauſes there are to which I thinke we may probably refer the Temperature of thoſe places, where the air is but moderately warm. To which a Third is to be added; when we come to give an account, why ſome places are troubleſomly hot.

And

And first, why the Coldnesse of Winter should not be felt in the Lowermost Region of the Earth may be, that the air there, is too remote from the Superterrestriall air, to be much affected with those adventitious Causes of Cold, that make that Quality intense in the air above ground. But because this Reason shews rather, why it should not be in the Earths Lower Region much Colder in *Winter* then in *Summer*; but not why it should be in all seasons warm there, I shall add as a Conjecture, that the positive cause of the actuall warmth may proceed from those deeper parts of the Subterraneall Region, which ly beneath those places which men have yet had occasion and ability to dig. For it seems probable to me, that in these yet inpenetrated Bowells of the Earth, there are great store-houses of either actuall Fires, or places considerably Hot, or, (in some Regions) of both; from which *Reconditories* (if I may so call them) or magazines of hypogeall heat, that quality is communicated, especially by Subterraneall Channells, Clefts, Fibres, or other Conveyances, to the less deep parts of the Earth, either by a propagation of heat through the substance of the interposed part of the Soil. (as when the upper part of an Oven is remisly heated by the same Agents that produce an intense heat in the Cavity,) or by a more easy diffusion of the Fire or heat through the above mentioned Conveyances as may be exemplified by the pipes that convey heat in some Chymicall

micall ſtructures:) Or elſe, (which is perhaps the moſt uſuall way,) by ſending upwards hot minerall Exhalations and Steams, which by reaſon of the comparatively heavy materialls they conſiſt of, and by reaſon of their being leſſe diſperſed nearer the places whence they proceed, are uſually more plentifull in the deeper parts of the Earth, and ſomewhat affect them with the Quality that they brought from the workhouſes where they were form'd and that they retain for ſome time after.

CHAP. IX.

THat manifeſt Steams oftentimes are found in Grooves, eſpecially in deep ones is evident, by the damps that infeſt moſt of them, and that in diſtant Regions, as in ſeverall provinces of *Germany*, *Bohemia*, *Hungary*, &c. as alſo in ſeverall parts of *England* in Grooves, ſome of which I have received Relations from the mine-men themſelves. By which it appears, that ſeverall of theſe Exhalations aſcending from the entralls of the Earth are ſulphureous & Bituminous in ſmell and in ſome Grooves (one whereof I elſewhere mention my ſelfe to have viſited) theſe Steams are apt, actually to take fire.

The warmth of many Subterraneall Exhations I thinke may be made further probable by ſome other Obſervations. For though theſe newly mentioned

mentioned are not to be rejected, and may be employed for want of better; yet I have severall times questioned, whether I ought to acquiesce in them alone. For I do not thinke the easy inflammablenes of Bodies to be alwaies a sure proofe of the actuall sensible warmth of the minute parts it consists of, or may be reduced into. For though Salt-peter be very inflammable, yet being by a solution in fair water reduced to invisible Corpuscles, it highly refrigerates that Liquor. Nor have I observed its fumes, (when far from the Fire,) to have any heat sensible to our Touch. And the like may be said of the *Exhalations* of highly rectifi'd spirit of Wine; which yet we know is itselfe totally inflammable. Nay I know not whether, (for a Reason elsewhere declared) copious Exhalations may not ascend from the lower parts of the Earth, and yet be rather Cold then Hot. For (in another Paper) I mention a way by which I made a mixture that plentifully enough emitted Steams, of whose being rather of a Cold, then hot nature, there was this probability, that the mixture whence they ascended even whilsts its component Ingredients were briskly acting upon one another, was not only sensibly, but considerably Cold.

One main thing therefore that induces me to assent to the Opinion, whereto the former Instances do but incline me, is, That having purposely inquired of an observing man that frequented deep mines, (wherein he had a considerable share,) he

he answered me, that he plainly observed the fumes that came out of the mouths of the deep pits, to be actually and sensibly warm, and that in a warm season of the year. And *Morinus* (above cited) speaking of the deep *Hungarian-mines*, makes it the first Epithite of the copious Exhalation that ascended from the bottom, that it was *hot*. And a few pages after he says, that at the mouth of the Well, the ascending Fumes were *sensibly hot in Summer it selfe*. And the same Arguments that I have elsewhere given to shew that there are very hot places, and as it were Æstuary in the Bowells of the Earth, may serve to make it probable that the steams ascending thence may be actually warm.

That also in many places of the Earth, where no Grooves are dugg, and no visible Exhalations are taken notice of, they may yet pervade the Soil, and exercise some operations of warmth, may be probable by this, that the experienced *Agricola* himselfe reckons it among the signs of a latent minerall vein, that the hoar-frost does not ly upon that tract of the Surface of the Earth, under which a vein (though perhaps very deep) runs. The like Directions I have known given by the skillfull in *England*, for the Discovery of places that contain Coal-mines. And I remember a near relation of mine shewed me a great scope of Land of his, which (though in an outward appearance, likely to be as cold as any place thereabouts,) he affirm'd would not suffer Snow to ly upon

upon it above a day or two in the midst of *Winter.*

The probability of which Relation was confirmed to me by the answer I received from a very ingenious Gentleman who lives among mines, and is not a little concern'd in some of them. For having inquired of him, What he had observed about the lying, or not lying of the *Snow* on the minerall Soils near the place of his Residence; he replyed, that in some of them, he did not take notice of any peculiar Indisposition to let the Ice and Snow continue on them; which I conceive may proceed, either from the want of such mineralls in the Subjacent parts, as were then in the state of Incalescence; or else from this that, (according to what we have elsewhere observed about the Snows on *Ætna*) the direct ascension of the hot Steams was hindered by some Layers of Rocks or other Stone, through which the Steams could not penetrate, or could doe it but so slowly, as to loose their actuall warmth by the way. But this Gentleman added that in other places, near that of his abode, and such as he knew to have minerall-Veins beneath them, he observed that the Snow, (nor the Ice) would scarce continue at all upon the Surface of the Ground, even in an extraordinarily cold winter.

It will be a considerable Instance to our purpose if it be indeed true which some learned men have written that near the Gold-mines in Hungary

pary the leaves of the trees, (especially those that respect the Ground) are ostentimes found ennobled with a golden-colour from the metalline Exhalations of the Gold-mines: which one would think must by reason of their ponderousnesse need a considerable heat to elevate them, especially into the open Air. But though doubting of this Relation, as not made by mineralists or accurate Observers, I inquired about it of a person, whose Curiosity carried him purposely to visit those mines, I was answer d that he could not be a witnesse to the truth of the Observation; yet he told me, an observation (which *I* elsewhere mention) that doth not discountenance that Tradition.

If it be objected that what has hitherto been said about Latent Fires and heats in the Bowells of the Earth will give an account of the warmth only of those places that are within reach of the action of such Magazines of heat, which probably may be wanting in many places of the Earth, I shall readily confesse, that as I first made this Objection to my selfe, so I do not yet discern it to be unreasonable, and that for ought I know if men had occasion to digg as deep and be as far conversant in many other low places of the Earth, where there are no signs of Mineralls, as they have done where the hopes of actuall discovery of veins of metalls, and other mineralls worth working, have invited them, divers places in the Third Region of the Earth would be met with, that would

bedestitute of the warmth that has hitherto been generally found in places of the same Regionthat either abound with mineralls themselves, or are near some of the deep and latent Æstuaries above-mentioned.

And as for those parts of the Third Region of the Earth, which men feel not only warm, but troublesomly hot, that incommodious degree of heat seems not, (at least in some places) to be derivable from the two above mentioned causes; which must, (to produce so considerable an effect) be assisted by a third cause more potent then themselves: which seems to be the incalescence there is produced in many mines, and other Places, by the mutuall action of the component parts promoted by water of immature and more loosely contexed mineralls, especially such as are of a Marchasiticalll nature. That such an Incalescence may by such a way be produced in the Bowells of the Earth, I have elsewhere shewn (in my discourse of *Subterraneall* Fires & heats) by the examples of such incalescences producible in minerall Bodies here above ground. That Marchasites which for the most part abound in Vitriol, are bodies very fit to procure this *Subterraneall* heat, may be confirm'd not only by the Sulphureous and *Saline* parts they abound with, and by this, that many of them may be wrought on, as we have tryed, both by simple water, and even by moist Air, which argues the resolubleness of their Constitution: but also by this,

this, that having purpoſely inquired of a Gentleman that went out of Curioſity to viſit one of the deeper Hungarian-mines, he confirmed to me what I had otherwiſe been informed of, by anſwering me, that in the lower parts of the mine, he had gathered Vitrioll that appeared above ground to be of a golden nature; and that in a Cave that is on one ſide of the Groove, in the deep Gold-mine near *Cremnitzo*, the corroſive ſmell is ſo ſtrong and noxious, that men have not dared to dig out the native Gold it richly abounds with, being deterr'd by the ill fate of divers that ventured to work in it. Adding that though he paſſed by it, in great haſt; yet he could not avoid the being offended by the noyſome Exhalations. And on this occaſion, 'twill not be (I preſume) diſliked, if I illuſtrate what I was ſaying of Immature mineralls, by ſubjoining, That having, asked this Chymiſt whether the Vitrioll he found very deep underground were all ſolid, or ſome of it ſoft? he affirm'd that as he gathered it, he found ſome of it ſoft. And to ſatisfy my curioſity to know whether it continued that yeilding conſiſtence? he further told me, that it was ſoft in the deeper part of the mine, but when he had brought it into the Superterreſtriall Air, it hardened there and appeared to have 9 divers golden ſtreakes in it.

CHAP. X.

ONe thing there is, which muſt not be here omitted

omitted, though it will probably be great news to those that philosophize only in their studies, and have not received information from any that visited the deeper parts of the Earth: The *Phænomenon* is this, That the Diggers in mines having found by unwelcom experience that in deep Grooves, the Air (unless ventilated and renewed) dos in a short time become unfit for respiration, have been put upon this expedient, to sinke at some convenient distance from the Groove where the miners worke, another pit (by some called a vent pitt) that usually tends directly downwards (though sometimes it make Angels) to which our English-minemen do in severall parts of this Kingdom give differing names; whereof the most significant seems to be that given it in the Leadmines of *Darbyshire*, where they call it an *Air-shaft*, and are wont to make it 40, 50, and sometimes 80 or 100 paces off, and, (as one of the cheife and skillfull Miners there informed me) as deep as the Groove or Well; (Though I find that the best *German* and some *English Miners* think a less depth will often suffice) From this Air-shaft to the Groove the men work in, there passes a Channell or if I may so call it, *Ventiduct* to convey the Air from the former to the latter; which is that, that *Agricola* sometimes (for he employs not the Terme alwaies in the same sense) denotes by his *Cuniculus*; and which though differingly nam'd by our Miners in severall parts of England is

Lib V. & VI. De re metall.

is in the above mentioned Lead-mines called a *Drift*, because the Air dos usually in the form of Wind drive thorow it: and thereby enables the Workmen to breath freely and conveniently enogh at the very bottom of the Well. On this occasion I remember that a very observing man who much frequented these Mines told me, that at the depth of no less then about 200 yards, he found that by the help of the Air-shaft, the Air was not only very commodious for Respiration, but temperate as to heat and Cold. And when I further asked, what time of the year it then was? he told me 'twas about the latter end of *August* and the beginning of *September*.

Now that which seems to me to deserve a farther and accurate observation about the motion and Temperature of the Air in these Artificiall under ground Cavities, is a Relation of *Agricolas* which, (though he be the most Classick Author we have about mines,) has not (that I know of) been taken notice of, in him. For this experienced VVritter, though in his Treatise * *de Ortu & causis Subterraneorum*, he only sayes indefinitely, that by means of the *Cuniculus or Drift*, which connects the Air-shaft & the well, that Air which comes in at one of those two, passes out at the other; yet in his Fifth Book *de*

Ideirco fcrobes, putei cuniculi effossi complentur externo Aere. Atque ipsum in eos influere imprimis hyemali tempore evidens est in duobus puteis, ad quorum utrumque ex modico intervallo cuniculus aliquis pertinet. Nam Aer in unum continuo influit rectâque per cuniculum permeat & transit ad alterum; atque ex eo rursus evolat foras.

de re metallicâ he gives a more particular and odd account of the course of the Air in these not over clear Terms, *Aer autem exterior se suâ sponte fundit in cava terræ, atque cum per ea penetrare potest, rursus evolat foras. Sed diversâ ratione hoc fieri solet; etenim vernis & æstivis diebus in altiorem puteum influit, & per cuniculum vel fossam latentem permeat, ac ex humiliori effluit similiter iisdem diebus in altiorem cuniculum infunditur, & interjecto puteo defluit in humiliorem cuniculum atque ex eo emanat. Autumnali verò & hyberno tempore, contra in cuniculum vel puteum humiliorem intrat, & ex altiori exit: verum ea fluxionum Aeris mutatio in temperatis Regionibus fit in initio veris, & in fine Autumni: in frigidis autem, in fine veris & in in initio Autumni.* To which he adds that which is more remarkable; That the Air in both the mentioned times, before its wonted course come to be durably setled, uses to be for the space of a fortnight liable to frequent changes, sometimes flowing into the upper or higher groove or Drift, and sometimes into the lower, (and passing out at the other.) If this Observation constantly hold, though but in some deep Mines, it may hint some old inquiries, about considerable and *Periodicall* changes in the *Subterraneall* parts of the Earth, or in the Air, or in Both; which though they have not yet been considered deserve

Sed Aer utroque tempore antequam cursum suum illum consuetum constanter teneat plerumque quatuordecem dierum spatio crebras habet mutationes, modò in altiorem puteum vel cuniculum influens, modò in humiliorem.

to

be ſo. I have endeavoured to learn whether any ſuch thing has been obſerved in ſome deep Lead-mines, whence I have procured divers informations about other particulars. But a very obſerving Perſon, that had the chief hand in contriving the *Subterraneall* ſtructures there, aſſured me that both *VVinter* and *Summer*, the current of Air went conſtantly the ſame way: the Air entring in at the Mouth of the *Air-ſhaft*, and coming out at the *Perpendicular Groove*, which takes its denomination from a *Cave*, (or *Caſa Puteali's*) uſually built over the Orifice of it, to ſhelter the Workmen from rain, and other inconveniences.

And ſince the writing of this, I found in *Morinus* (his Relation already mentioned) a paſſage that may ſomewhat illuſtrate the darkly expreſt Obſervation of *Agricola*. For the lately mention'd Author writes, that in the deep *Hungarian* Mines he viſited, the outward Air paſſed (firſt) through the Burrows, and ſo through By-waies, (if I may ſo call them) that tended not directly downwards, reacht at length to the bottom of the *VVell*, or perpendicular Groove, whence, together with the *Steams* proceeding from the Mine) is aſcended ſtrait upwards. But *Morinus* taking no notice at all of *Agricola's* Obſervation about the differing courſe of the *Subterraneall* Air at differing *Seaſons* of the year: *though* (as I find by what he writes elſewhere,) 'twas Summer when he viſited the Mines, and ſo what he reports,

reports, agrees well with one part of what *Agricola* seems to say; *yet*, as to the other, and principall part of his Observation, he says not any thing. And the sensible heat he ascribes to the steams ascending out of the perpendicular Well, leaves it somewhat dubious, what interest the Rarefaction of the Air, by the *Subterraneous* Heat may have in the *Phænomena* we have been discoursing of.

But to return to what I was saying before I had occasion to mention *Morinus*. Which perhaps it will not be impertinent to add, that I learn'd by inquiry, that the *Air-shafts*, and the Wells, were in these Mines much of a depth. But I hope ere long to have accounts of what happens in other mines, in other parts of England, as to the course of the *Subterraneall* Air especially when its issuing out of the Well, or the *Air-shaft* depend not on the changes of the Winds that blow above ground: And I wish the curious would employ the like endeavours in other Countries.

For indeed what I have hitherto discoursed in this Treatise, is *accommodated* but to the scant Information I have hitherto receiv'd; and therefore ought to be *rectified* or *Confirmed* by farther Informations if they can be procur'd.

In the mean time, I think I may probably enough, gather from the pas't Discourse, that though in some Mines, three *Subterraneall* Regions, and their distinguishing Attributes, may be

be not inconveniently aſſigned; yet generally ſpeaking of the whole Body of the Terreſtriall Globe (as farr as we know it) both the Bounds and the Temperature of the Regions of the Earth, as well as thoſe of the Air, are various and uncertain enough.

And much leſs have we any certain knowledge of the Temperature of the more inward, and (if I may ſo ſpeak) the more Centrall parts of the Earth; in which, whether there be not a continued ſolidity, or great Tracts of Fluid matter, and whether or no, differing Regions are to be diſtinguiſhed, and what their number, Order, thickneſs, and qualifications may be, we are as yet ignorant, and ſhall I fear long continue ſo, For it is to be noted (with which obſervation I ſhall conclude) that what has been hitherto diſcourſed, belongs only to the Temper of thoſe *S*ubterraneall parts, to which men have been enabled to reach by Diging. 'Tis true indeed that ſome Mines eſpecially in Germany, and Hungary are of a *S*tupendious depth, in compariſon of the generality of ours, and of the more obvious Cavities of the Earth; yet I find it boaſted in a Diſcourſe written purpoſely of the Various Mines, in the VVorld, that the rich Mine at *S*ueberg is 400 yards deep: And they are ſcarce believed, that relate one Hungarian-Mine which they viſited to be 400 fathom; which though double the depth of the former, reaches not to half a mile. But the deepeſt of all the mines that I have as yet read or heard of, from any credible

dible Relator, is that which the experienced *Agricola* in the Tract he calls *Bermannus*, *Cap.* 12. mentions to be at *Cotteberg*. But this it self though it reach to above 500 fathom, that is, 3000 foot, yet this prodigious depth dos not much exceed halfe a mile & fals short of three quarters; and how small a part is that of the whole depth of the Terrestriall Globe? whose semidiameter, if we admit the recent account of the Learned *Gassendus*, reckoned at 4177. Italian miles: in comparison of which, (as I was saying,) how small a thing is a depth that falls very short of a single mile?

Licet variæ de ambitu terræ opiniones sint, nobis tamen propemodum constet, esse ipsam milliarum Italiarum 26255, *quod in maximo ad Terræ superficiem circulo respondeant uni gradui milliaria proximè* 73. *&c. Gassend. Instit. Astronom. Lib.* 2. *Cap.* 13.

FINIS.

Of the

TEMPERATURE

Of the

SUBMARINE REGIONS

As to *HEAT* and *COLD*.

OF THE TEMPERATURE, Of the SUBMARINE REGIONS.

As to Heat and Cold.

CHAP. I.

THough the *Aristotelians* who believe water and Aire to be reciprocally transmutable, doe thereby fancy an Affinity between them, that I am not yet convinced of: yet I readily allow of so much Affinity betwixt those two fluid Bodies, as invites me (after having treated of the Temperature of the Aeriall Regions) to say something of that of the Submarine Regions: which name of *Submarine*, though I know it may seem Improper, I therefore Scruple not to make use of, because even among the Generality of Learned Men Use has Authorized the name of *Subterraneous Places*. For as these are not by this name, and indeed cannot in Reason be supposed to be beneath the whole Bodie of the Earth, but only the *Superficiall* parts of it: so by the Appellation of *Submarine Regions* 'tis not to be supposed that the places so called are below

the Bottom of the *Sea*, but only below the ſurface of it.

But to come from words to things, I preſume it will not be expected that I that never pretended to be a Diver ſhould give of the Regions I am to treat of, an Account build on my own Obſervations; and I hope it may gratifie a Reaſonable Curioſity about a ſubject, of which Claſſick Authors are ſo very ſilent, and about which Philoſophers ſeeme not ſo much as to have attempted any Experiments (for want of Opportunities and mean to make them.) I offer the beſt Information I could ſupply my ſelfe what by purpoſely converſing with Perſons that have dived ſome without, and ſome by the help of *Engins*. To which I have added ſome reports that I judge fit to be allowed, made me by Perſons that had converſed with the Divers upon thoſe Affrican and Indian Coaſts, where the moſt famous and expert are thought to be found.

And I the rather report the Anſwers and Relationsmy Inquiries procur'd becauſe the Informations they give us concerne a ſubject conſiderable as well as vaſt, about which nevertheleſſe I among many others am not in a condition to ſatisfie at all my Curioſity by Tryalls of my own making, and becauſe alſo what I ſhall ſay will probably ſpoile the credit of the Vulgar Error that in all deepe water of which the Sea is the Cheifeſt, the lowermoſt are ſtill the warmeſt parts, unleſſe in caſe that in ſome very hot Cli-

mates

mates or ſeaſons, the ſuperficiall ones happen to be a little warm'd by the Extraordinary or Violent heat of the *Sun*.

CHAP. II

THough the Air and the Earth have been diſcriminated as to Temperature into three Regions; yet the Informations I have hitherto met with, invite me not to aſſign to the *Sea* any more then two. The former of which may be ſuppoſed to reach from the ſuperficies of it, as far downwards as the manifeſt operation of the variouſly reflected and refracted Beames of the *Sun*, or other Cauſes of warmth penetrates: from which to the Bottom of the *Sea*, the other Region may be ſuppoſed to extend.

According to this Diviſion the Limits of this upper Region will not be alwaies conſtant; for in the Torrid Zone and other hotter Climates, it will, *Cæteris paribus*, be greater then in the Frigid Zone or in the Temperate Zones: and ſo it will be in *Summer* then in *Winter*: and in hot weather then in Cold; ſuppoſing in theſe Caſes the Heat to come from the Sun and Air; and not, as ſometimes it may do, from the Subterraneall Exhalations.

The ſame cauſes are likewiſe proper as 'tis manifeſt to alter the Temperature as well as the Bounds of this Region, But this Temperature

may also be changed in some few places by at least two other Causes; The one is the differing constitution of the Soil that composes the Shore, which may affect the neighbouring water if it doe extraordinarily abound with Nitre, loosely contexed marchasites, or other substances capable considerably to encrease or lessen the Coldnesse of the water. Another though unfrequent Cause, may be the figure and situation of the lesse deep parts of the Shore, which may in some sort reverberate the Heat that proceeds from the *Sun*; and upon such an account may either add to the warmth, or allay the Coldnesse that would else be found in the neighbouring water. For whatever the *Schools* are wont to teach about the Interest of the Attrition of Air in the heat produced by the *Sun Beams*, I have elsewhere shewn by Experiments, that those Beams may considerably operate upon Bodies placed quite under water.

Besides these two Cases that may occasion Exceptions to the generall Observation; I intimated by the words, *at least*, that there might be others. Because, to mention now but one Example, though it seem probable from what I have elsewhere delivered concerning the *Subterraneall* Fires and Heats, that may in some places be met with, even beneath the bottom of the *Sea*, that the *Phænomenon* I am going to recite may be reduc'd to the causes newly intimated; *yet* I am not absolutly certain but that in this case, whereto some others may perhaps be found resembling, some other

cause

cauſe, then thoſe hitherto mentioned, may produce or concurre to the effect. The Relation here meant is afforded us by the following Paſſage, taken out of the Voyage of *Monſieur de Monts* into *New-France*, (whereof he went to be Governor) where the Relator thus recites his obſervation. *About the eighteenth day of June we found the Sea-water* during three dayes ſpace very warm, and by the ſame warmth, our wine alſo was warme in the bottom of our ſhip; yet the Air was no hotter then before. And the 21 of the ſaid moneth, quite contrary, we were 2 or 3 days ſo much compaſſed with miſts and cold, that we thought our ſelves to be in the moneth of *January*, and the water of the *Sea* was extreame cold: which continued with us untill we came upon the Bank by reaſon of the ſaid miſts, which outwardly did procure this cold unto us. This effect he attributes to a kind of Antiperiſtaſis in the following part of his narrative; which I ſhal not now either tranſcribe or examine.

CHAP. 3

And thus much being breifely noted touching the upper Region of the *Sea*, and the requiſite Cautions (that may perhaps extend further then it) being premiſed; it remains that I take notice of the Temperature of the Lower Region, which, in one word, is Cold (unleſſe in ſome few places to be preſently mentioned.) For water being

ing in it's naturall or most ordinary state, a liquor whose parts are more slowly agitated then those of mens Organs of Feeling, must be upon that account Cold as to sense: and consequently it need not be strange that those parts of the Sea, which are too remote to be sensibly agitated by the Sun-Beams, or wrought upon by the warmth which the Air and upper parts of the Earth may from other Causes receive, should be felt Cold by those that descend into it; unlesse in those few places where the Coldnesse may be either expell'd or allay'd by hot Springs or Subterrestriall Exhalations, flowing or ascending from the subjacent Earth, or the lower parts of the shore into the incumbent or adjacent parts of the water.

To justifie my ascribing of this Coldnesse to the second, or lower Region of the Sea, I shall now subjoin some Relations I procur'd from persons that had occasion to goe down into it, or otherwaies take notice of its Temperature in very differing Regions of the World, and at very unequall depths.

And first as to the Temperature of the lower Region in the *Northerne Sea*, I had the opportunity to converse often, and sometimes to oblige a man bold and curious enough, who for some years got the best part of his subsistence by descending to the bottom of the Sea in an Engin, whose structure I elsewhere describe, to seek for, and recover Goods lost in Shipwrackt Vessels. This person I diligently examined about divers

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Submarine Phænomena, about which his anſwers may be elſewhere met with. And as to the Temperature of the lower parts of the Sea (the knowledge of which is that alone that concerns us in this place) he ſeverall times complained to me of the Coldneſſe of the deep water, which kept him from being able to ſtay in it ſo long as he might have been put into a condition of doing by the goodneſſe of his Engin; for I remember that he related to me that he ſtaid once betwixt an hour or two, at a depth that was no greater then 14 foot and a half upon the coaſt of Sweden, in a place that was near the ſhore; and I afterwards learnd that he ſtaid much longer in a deeper place; (uſe having probably made the Cold more ſupportable to him) He told me then, that about two years before he was engaged by a good reward to goe down with his Engin to the bottom of the Sea to fetch up ſome Goods of value out of a Ship that had been caſt away there within about a miles diſtance from a very little Iſland, and if I miſtake not about *6* miles from the Shore. He farther anſwered me that though he felt it not at all Cold on the Surface of the Water (his attempt being made in *June*) yet about the depth of the Ship, it was ſo very Cold, that he felt it not ſo Cold in *England* Winter and Froſty VVeather. And he told me that an exceſſive Cold was there felt not only by him but by very ſturdy men, who invited by his example, would needs alſo goe down themſelves to participate and promote the

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hoped for Diſcovery. He told me alſo, that the upper water did but cool and refreſh him; but the deeper he went the Colder he felt it, which is the more conſiderable, becauſe he had ſome times occaſion to ſtay at 10 fathoms or even 80 foot under water. And I ſince found that he informed divers Virtuoſi, that purpoſely conſulted him, that he found the Coldneſſe of the Water encreaſe with its depth: and gave that for the reaſon why he could not ſtay ſo many hours as otherwiſe he might, at the bottom of the *Sea*. Adding that before his Engin was well fitted, he was once ſo covered over with it, that he was forced to touch the ground with his hands and feet, and the neighbouring parts, to which he found a Coldneſſe communicated by the *Fundus* he lean'd upon; though the cloſeneſſe of his diſordered Engin made the other, and (whilſt he was in that poſture) upper parts of his Body, of a very differing Temper.

An inquiſitive perſon of my acquaintance that made a long ſtay in the *Northerne America* (at about two or three and forty degrees of Latitude) and diverted himſelfe often with ſwimming under water, anſwered me, that though he ſcarce remembred himſelfe to have dived above two fathoms beneath the ſurface of the *Sea*; yet even at that ſmall depth, he obſerved the water to increaſe in coldneſſe, the lower he deſcended into it. Which argues, that though the Sun-Beams do often penetrate plentifully enough to carry light

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to a great depth under water; yet they doe not alwaies carry with them a ſenſible heat: and that at leaſt in ſome places, the upper Region of the *Sea* reaches but a little way.

The coldneſſe of the Climate in theſe weſtern parts of Europe, and the want of conſiderable inducements to invite men to dive often to any great depth into our Seas, has kept me from being able to procure many obſervations about the temperature of their lower Region, but upon the hotter Coaſts of Africk, and the Eaſt-Indies, the frequent Invitations men have to dive for Corall, pearles, and other *Submarine Productions*, has made it poſſible for me to get more numerous obſervations: ſome of which I ſhall now annex.

CHAP. 4.

MEeting with a Perſon of Quality who had been preſent at the fiſhing of Corall upon the ſhoar of Africa, and Who was himſelfe practiſed in diving, I inquired of him whether he found the *Sea* upon the African Coaſt to be much colder at a good depth, then nearer the ſurface; whereto he anſwered me, that though he had ſeldome dived above three or four fathoms deep, yet at that depth he found it ſo much colder then nearer the Top of the water, that he could not well endure the coldneſſe of it.

And when I farther asked him whether when he

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was let down to the bottom of the *Sea* in a great diving Bell (as he told me he had been) he felt it very cold, though the water could not come immediately to touch him, he replyed that when the bell came first to the ground, he found the Air in it very cold, though after he had ſtaid a while there, his breath and the ſteams of his Body made him very hot.

That alſo at a greater depth in thoſe hotter Climates the *Sea-water* is ſenſibly Cold may be thus made probable, Inquiring of a famous *Sea*-Commander who had been upon the Affrican Coaſt, to what depth he was wont to ſinck his Bottles to preſerve his Wine any thing coole in that exceſſive hot Climate, he Anſwered me that in the day time he kept it in a tolerable temper ſo as to be drinkable, by keeping it in the Bottom of the ſhip, and in ſand, but in the morning he had it coole enough by ſincking his Bottles over night into the *Sea*, and letting them hang all night at 20 or 30 fathom deepe under water.

Inquiring alſo of an intelligent Gentleman that was imploy'd to the river of Gambra, & ſayl'd up 700 miles in it, in a ſmall frigot, whether he had obſerved that in the *Sea*, even of thoſe hot climats, wine may be preſerved coole, he told me that it might, and that by the means I hinted to him, which was to let down when the ſhip came to an Anchor in the Evening ſeverall Bottles full of wine (they uſed that of *Madera*) exactly ſtoped to ten, 12, or 14 fathoms deep, whence being the next morn-

morning drawn up, they found the wine coole and freſh (as if the veſſels had been in theſe parts drawne up out of a well) provided it were preſently drink, for if that Circumſtance were omitted, the heat of the Aire on the upper part of the water would quickly warme the Liquor.

I remember too, that having met with a man of Letters that ſail'd to the Eaſt-Indies in a *Portugal-Caract*, I learnt by enquiry of him, that 'twas the practice in that great Veſſell for the Captain and other Perſons of note, whilſt they paſſe through the Torrid Zone, to keep their Drink, whether Wine or Water, cool, by letting it down in bottles to the depth of 80, 90, anc ſometimes an hundred Fathom or better, and letting it ſtay there a competent time; after which he told me he found it to be exceeding cool and refreſhing.

Laſtly, to ſatisfie my ſelfe as far as I could, to how great a depth the Coldneſſ of the Sea reached; meeting an obſerving Traveller whoſe affairs or Curioſity had carried him to divers parts both of the Eaſt and VVeſt-Indies, I enquired of him whether he had taken notice of any extraordinary deep ſoundings in the vaſter ſeas, To which being anſwered, that ſome years agoe ſailing to the Eaſt Indies in a very great ſhip, over a place on the other ſide the Line that was ſuſpected to be very deep, they had the Curioſity to let down 400 Fathom of Line, and found they needed no leſſe. Whereupon I enquired of him, whether he had

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taken notice of the Temperature of the ſounding Lead aſſoon as 'twas drawn up: To which he told me, that he, and ſome others did; and that the Lead which was of the weight of about 30, or 35 l, had received ſo intenſe a degree of coldneſſe as was very remarkable; inſomuch that he thought that if it had been a maſſe of Ice, it could not have more vehemently refrigerated his hands: and when I asked in what Climate this obſervation was made, he told me 'twas in the Antarctick Hemiſphere, but at a great diſtance from the Line. As indeed I concluded by ſome Circumſtances he mentioned to me, that 'twas about the 35th degree of Southern Latitude.

CHAP. 5.

These are the cheife Relations I have hitherto been able to procure about the Temperature of the *Sea*; which if they be ſo confirmed by others, as that we may conclude they will generally hold; it wil not be irrational to conceive that in reference to Temperature, thoſe two Fluids, *Air* and *Water*, may have this in common, that where their *Surfaces* are contiguous, and in the neighbouring parts, they happen to be ſometimes cold, and ſometimes hot, as the particles they conſiſt of, chance to be more or leſſe agitated by the variouſly reflected *Sun-Beams*, or more or leſſe affected by other cauſes of Heat.

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But that part of the Air which they call the ſecond, & is ſuperior to the firſt, as alſo the lower Region of the Sea, being more remote from the operation of thoſe cauſes, doe retain their naturall or more undiſturbed Temperature, which, as to us men, is a conſiderable degree of coldneſs, the Agitation of their ſmall parts being uſually in thoſe Regions much inferior to that of the *Spirits*, *Blood*, & other parts of our Organs of Feeling. *So* that the Regions of the *water* and *Air* ſeem to anſwer one another; but in an inverted order of ſituation, and the *Analogie* might perhaps be carryed further, if I had time and opportunity to doe it in this place. And here I ſhall not diſſemble that I was ſomewhat perplexed by meeting with a traveller that had viſited the *Eaſt-Indian Coaſt*, near the famous *Cape* of *Comory*: for asking him ſome queſtions touching the neighbouring *Sea*, *I gathered* from his diſcourſe, that he concluded from that of ſome Divers, that the *Sea* near *Ceylom* was warmer at the bottom then at the top. And when I thereupon asked him *whether* this happened not in their *Winter*, he replyed that it was indeed Winter, though not with us, yet with them; it occurr'd indeed to my thoughts on this occaſion, that perhaps in a part of the Torrid Zone ſo near the Line as about 80 degrees, if the *Sea* were not of a conſiderable depth, the heat of the two not far diſtant ſhores of *Coromandell* and *Ceylom* might have no ſmall influence upon the Temperature of the water. I conſidered alſo (which did

did not a little weigh with me) that in divers parts of the East-Indies, and even in a Region bordering upon *Coromandell*, where an ingenious Acquaintance of mine lived some years, it has been observed, that *Winter* and *Summer* are not so much discriminated by Cold weather & Hot, as by very Rainy weather and very dry. Nay in some places the sultry heat of the Climate is more complained of, in what they call their *Winter* then their *Summer*. So that there will be no necessity to recur to an *Antiperistasis* occasioned by the coldnes of the *Winter*. I thought too, that it may perhaps be without absurdity suspected, that as the bottom of the *Sea* in this place had a peculiar Constitution that fitted it more then others for the copious production of pearls: so there might be some peculiarity in the nature of the subjacent Soil, or there may be some Subterraneall Fire or heat beneath it, which may occasion an unusuall warmth in that part of the Sea, by wch cherishing warmth, perhaps such abundance of shell Fishes teeming with pearls, may be invited to settle there rather then in any of the neighbouring places. But with all these conjectures, I should not have been so well satisfied, as with the answer I afterwards obtained by a Gentleman whose Curiosity had carried him to be an assiduous *Spectator* of the famous pearl-fishing near the *Island* of Manar; between that and the Coast of *Coromandell*, which reaches near, if not fully to the *Cape* of *Comoris*. For this Person having had much Conversation with the

Divers

Divers for Pearls, not only learn'd from them, that they found the water very ſenſibly Cold at the bottom which in ſome places he eſtimated to be 80 or 100 fathom deep; but obſerv'd divers of them at their return to the Boats, to be ready to ſhake with Cold, and haſten to the fires that were kept ready for them in little Cabines upon the ſhore: Which Relation being accompanied with divers Circumſtances of credibility and arguing the perſon that made it to have been acquainted with the report above mentioned, and had met with ſome that had dived in the place whereto it had relation, made me conclude that as to that report hither ſomething extraordinary had happened in that place, or that there was ſome miſtake of him to whom 'twas made, or that divers did not deſcend to a ſufficiently conſiderable Depth

If I had been furniſhed with opportunity, I would have engaged ſome ingenious Navigators to examine the Temperature of the Submarine-Regions, both of differing ſeaſons of the year (eſpecially the hotteſt part of *Summer* and Coldneſs of *Winter*, & with Hermetically ſeal'd Weatherglaſſes in order to the Diſcovery of ſuch Particulars as theſe, *Whether* there be in ſome *Seas* any ſuch varying Differences of Temperature, as may invite us at leaſt in ſome places, to make more then two Submarine Regions, Whether the Submarine Coldneſſe do at the bottom of the *Sea*, or elſewhere either Equall or

ſurpaſſe that degree which we here find ſufficient to freeze common water. *Whether* the parts of the Sea-water are ſtill the Colder, as they are the deeper, And *Whether* or no this increaſe of Coldneſſe be regular enough to be reducible to any ſettled proportion. But for the reſolving of theſe and the like Queſtions, I did not cauſeleſſely intimate that a ſealed Weather-glaſs was to be employed; for I take a common one to be altogether unfit for ſuch purpoſes, not only becauſe the Sea-water would mingle with ſuch Liquors as are wont to be employed in it, for that Inconveniency I could eaſily remedy, by ſubſtituting, as I have ſeverall times don in other caſes, *Mercury* inſtead of ordinary Liquors: but cheifely becauſe the incumbent Sea-water would gravitate upon the reſtagnant Liquor of the Weatherglaſs, and thereby render its Informations falſe or uncertain. According to what I have had occaſion to obſerve in another Tract.

Whereto, that there may not in this place be any need to recur, I ſhall add a ſlight experiment that I made for the ſatisfaction of ſome Ingenious men not well acquainted with *Hydroſtaticks*, or not rightly principled *in them*. And this Tryall I ſhall the rather mention, becauſe many will not allow Water to preſs upon *Mercury* immersd therein, *this* being a far more ponderous Liquor then that; and others will expect, that the included Air, having no place to eſcape out at, ſhould reſiſt the aſcenſion of the ſubjacent Mercury, more

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than indeed it will. We made then a ſmall Weather-glaſſe differing from common ones, (beſides the bigneſſe,) in that it was furniſhed with *Mercury* inſtead of *Water*; and in that we employed to contain the ſtagnant Mercury, a Glaſs Viall with a narrow neck, wherein (by a piece of Cork or two) the Stem of the Glaſs ball was well faſtened that this globula put of the Inſtrument might not be lifted up when it was under water. Then having by applying cold water to the outſide of the Ball endeavoured to reduce the Air to the ſame Temper with the Water, or at leaſt to an approaching degree of Coldneſſe; and having taken notice of the *Station* of the Mercury in the ſhanck or ſtem above mentioned; we did, (by ſtrings tyed about the neck of the ſmall Vial) let the Inſtrument gently down into a large tall glas Body filled with fair water: that the Liquor and Veſſell being both tranſparent, we might eaſily perceive the motions of the Mercury in the ſlender pipe. By which means it appeared, that as the *Thermometer* deſcended deeper and deeper into the Water, the Mercury was preſſed up higher and higher in the *Stem*. And that it may not be ſuſpected, that this aſcenſion proceeded only, or cheifely, from the refrigeration of the Air by the Water, I ſhall add to what I have juſt now noted, that though the Coldneſſe of the VVater may well be ſuppoſed uniform as at leaſt to ſenſe; yet the whole inſtrument being leaſurely removed ſometimes to the upper ſur-

face of the VVater. (The like Experiment we might have tryed with a *Thermoſcope* furniſhed with VVater and let into Oyl; or with deliquated *S*alt of Tartar and pure *S*pirit of VVine inſtead of Mercury and Water: if we had been furniſhed with ſufficient quantities of thoſe Liquors and had judged it to be requiſite.) But this Circumſtance, I thought fit to admoniſh the ſpectators of, that tis not to be expected, that the Mercury ſhould riſe as much in proportion when it is (for example) a foot under water, as when it is but two or three Inches; becauſe according as the Inſtrument is let down deeper and the Air crowded into a leſs room, the *S*pring of that compreſſed Air becomes the ſtronger and makes the more reſiſtance. VVhich Advertiſement agreed well with the Experiment, whoſe other *Phænomena* I pas over as not pertinēt to this place, where *I* would only juſtifie what I ſaid of the unfitneſſe of Weather-glaſſes made (though with other Liquors) after the Common waies for making the *S*ubmarine Tryalls I propoſed.

But till ſuch Artificiall Obſervations can be obtaind we may from what has been above delivered, probably gather that though the lowermoſt of the *S*ubmarine Regions be very ſenſibly Cold, yet VVater, at leaſt that of the *S*ea, does not by theſe *Phænomena* appear to be the *Summum Frigidum*. Though *I* have been ſeverall times able to produce Ice in *S*altwater, yet *I* find not by any Obſervation, that there has been *I*ce met with

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and generated at the bottom of the Sea, under which the Earth has been found unfrozen by our Divers; and appears to be ſoft at depths exceedingly ſurpaſſing the greateſt they have reacht; as is evident by the Mudd, Gravell, &c. fetch'd from the bottom of the *Sea* by ſounding plummets, let down to 80 or 100 fathom, or even a depth, whereof examples may be met with in the Journalls of Navigators; nay, my curióſity procur'd me this account, from the ſober Commander of a ſhip, that came this year from the remoter parts of the great Ocean, that at about 35 degrees of *S*outhern Latitude, the tallow with which his ſounding Lead was annointed brought him up gray *S*and from the immenſe depth of no leſs then two hundred & twenty Fathom. But to this Obſervation 'tis juſt to annex this Caution, That we cannot ſafely conclude from mens finding no Ice at the bottom of the *S*ea, that the Cold there cannot be very intenſe; for as I have found by more then one Relation (* elſewhere recited) that, whatever the *S*chools ſurmiſe, the *S*ea is at leaſt as *S*alt at the bottom, as at the top: ſo I have more then once tryed, that *S*alt water will without freezing admit a much greater degree of Cold, then is neceſſary to turn freſh Water into Ice.

* *Notes about the Saltneſſe of the Sea.*

FINIS.

and generated at the bottom of the Sea, under which the Earth has been found untrozen by our Divers; and applies to Soft and Depths exceedingly furnishing the great Ice, which is evident by the Mud, Gravel, &c. fetch'd from the bottom of the Sea by sounding plummet-lot down to Sea, or too fathom, or even a dozen, whereof examples may be met with in the Journalls of Navigators; nay, my curiosity prompt I me this account, from the sober Commander of a ship, that came this year from the remoter parts of the great Ocean, that at about 24 degrees of Southern Latitude, the tallow with which his sounding Lead was annointed brought him up gray Sand from the immense depth of no less than two hundred & twenty Fathom. But to this Observation I just to annex this Caution, That we cannot safely conclude from mens finding no Ice at the bottom of the Sea, that the Gold there cannot be very intense; for as I have found by more then one Relation (* elsewhere recited) that, whatever the School's furnishe, the Sea is at least as Salt at the bottom, as at the top: so I have more then once tryed, that Salt water will without freezing admit a much greater degree of Gold, then is necessary to turn fresh Water into Ice.

* Note about the Salt-ness of the Sea.

F I N I S.

RELATIONS

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BOTTOM OF THE SEA,

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BOTTOM OF THE SEA.

RELATIONS
about the
Bottom of the Sea.

The First SECTION.

I Do not pretend to have viſited the Bottom of the Sea, but ſince none of the Naturaliſts whoſe writings I have yet met with, have been there any more then I, and 'tis great rarity in theſe cold parts of *Europe* to meet with any men at all that have had at once the Boldneſſe, the occaſion, the Opportunity and the Skill to penetrate into thoſe conceal'd and dangerous Receſſes of Nature, much leſs to make any ſtay there, I preſume it will not be unpleaſant, if about a ſubject, of which, though none of thoſe very few Naturaliſts that write any thing at all, write otherwiſe then by hear-ſay, I recite in this place, what I have learn'd by Enquiry from thoſe Perſons that among the many Navigators and Travellors I have had opportunity to converſe with, were the likelieſt to give me good Information about theſe Matters.

It would be needleſs here to take notice, that the Sea is uſually Cold and Salt at the bottom, nor to repeat thoſe other Things that I have already

ready delivered in other Discourses. I shall therefore begin what I have to say in this, by relating that one of the chief things that I was solicitous to enquire after about the Bottom of the *Sea*, was, the inequality I supposed to be in the *Soil*. For though the surface of the *Sea* when 'tis not agitated by the winds, appears very plain and levell, and though it be indeed, at least in this or that particular *Sea*, *Spharicall* and (Physically speaking) concentricall to the earth; yet I could not think it probable, for Reasons not necessary to be here discoursed of, that the Bottom, the *Superficies* of the Ground, or of the Vessell that contained it, should be either flat or levell, or regularly concave.

To satisfy my selfe about this matter, I enquired of a Person that had visited the famous Pearl fishing at the little Island of *Manar* (near the rich Isle of *Ceylon*) in the East Indies, and had by his stay there much opportunity to see Divers at their Work and converse with them. By the Answers of this man who was a *Scholler*, I learnt, that the Divers had assured him, That they found the Floor of the *Sea*, if I may so call it, in divers places exceedingly unequall, in some places being flat, in others asperated with crabby Rocks a considerable height, and elsewhere sinking into precipitous depths in which they found it very cold.

Besides the recited Testimonies of the Divers, I enquired of severall Pilates and other Navigators

tors, that had made long Voyages, what gradu-all or abrupt inequality they had obſerv'd at their Soundings in very neighbouring places; it being eaſy to be gathered from thence, whether the Sea were there uniformly deep, or did at leaſt with ſome regularity alter its depth by degrees, or whether as I ſuſpected, there were not at the bottom of the Sea, hilly places, and ſteep Præcipices, and perhaps deep Vallies or Wells, as we obſerve in the diſcovered part of the Terreſtriall Globe.

By theſe inquiries I obtained ſeverall Obſervations, whereof the moſt materiall are thoſe that follow.

Firſt, An ancient *Sea*-Commander, that had many years frequented Africa and the Indies, told me as others had don before, that when they ſail'd in the Ocean very far from ſight of Land, they did not often put themſelves to the trouble of *Sounding*; but that as far as they had *Sounded*, he had uſually found the depth of the *Sea*, to increaſe or decreaſe gradually, without very great irregularities, excepting ſome places, inſtancing particularly in the Excavation that makes the Bottom of the *Sea*, within ſight of the *Cape of good Hope*, where though for the moſt part, he found the water to deepen more and more as he ſailed farther from the ſhore; yet in one place, he and others had met with a Bank (as he conceived it to be) at a conſiderable diſtance from the ſurface of the Water. So that though when they were

were as they imagined near the edge of that bank, they found but a moderate number of fathoms, yet when sailing a very little way farther, they had gone beyond it, they found the *Sea* of an immense depth. In short, I gathered from his Answers, that in the greater *Seas*, he had found for the most part, the ground at the bottom, to fall away by degrees; but nearer the shores, that is, within a moderate number of Leagues, he observed in divers places that the *Submarine* Ground was very unequall, and had as it were, Hills and Præcipices.

A man of Letters, that had sailed both to the East and West Indies, and in divers other Regions besides, and had made some of his Voyages in ships of such great burden, as obliged the Marriners to be very frequent and carefull in sounding, informed me, that some times at considerable distances from shore, he had observed the *Sea* to be 20, 30, or perhaps 40 fathom deeper when they cast the sounding Lead from one side of the ship, then it had been just before, when they had sounded from the other, and from other Things that he told me, I found my self much confirmed in the above proposed Opinion.

Hearing of a *Sea*-Captain of extraordinary skill in Maritine Affairs, that was come home this year from East-India, his reputation made me endeavour to have a little conference with him, about the subject of this discourse; but his occasions hastening him to another place before

I could ſend to him, *I* procur'd from the chief Perſons that employ'd him, a ſight of ſome Notes, touching his laſt Voyage, which he had left with them; hoping to find there ſomething at leaſt, about the *S*oundings of ſo accurate a *S*eaman, and accordingly I met with a Paſſage, very pertinent to my purpoſe, and worthy to be here tranſcribed.

Febr. 12. After our Obſervation, (he means a former one very agreeable to this) ſeeing the ground under us, we heav'd the Lead, and had but 19 fathom rocky ground, then hal'd by N.N. E^t. the Wind at N.W. and found our water to ſhoale from 19 to 10 and 8 Fathom hard Corall Ground, then ſuddainly deepned again from 8 to 20 and 22 fathom *S*andy Ground, and then ſuddainly ſaw Rocks under us, where we had but 7 fathom, and the next caſt 14 fathom again. And ſo having run N. N. E^t. from 6 in the morning till 12 at noon about 19 mile, we deepen'd our VVater, from 16 to 25, and the next caſt, no ground with 35 fathom of Line.

Laſtly, having opportunely met with an Ancient Navigator, who paſſes for the moſt experienced Pilate in our Nation for an Eaſt Indian voyage; *I* asked him about his own Obſervations concerning theſe unequall *S*oundings, *I* was anſwer'd, that he had not only met with them elſewhere, but that not far from the mouth of our Channell, he had ſometimes found the bottom of the *S*ea ſo abrupt, that in ſailing twice the Length

Length of the ſhip, he had found the VVater deepen from 30 fathom to a hundred, if not alſo much more.

Since I received theſe Relations, having the honour to diſcourſe with a Noble Perſon, who has divers times deſervedly had the command of Engliſh Fleets, and is no leſs curious then intelligent in Maritine affairs, I took the opportunity to inquire of his Lordſhip, whether he had not obſerv'd the bottom of the Sea to be very unequal in neighbouring places? To which he reply'd, that he had found it exceedingly ſo. And to ſatisfy me that he ſpoke not upon meer cõjecture, he told me that ſailing once with his Fleet even in our Channell, he perceived the VVater to make a rippling noiſe (as the Sea-men call it) as the Thames does under London Bridge. So that he was afraid they were falling upon ſome ſhoale, the VVater being 12 or 14 fathom deep, and going on a little farther, he caſt out the Plummet again, and found it about 30 fathom. He added that he made divers ſuch Obſervations, but took notice of ſuch rippling VVaters only when the Tide was ebbing: and yet in a deep Sea meeting with the like appearance in the upper part of the water, and thinking it improbable that there ſhould be any ſhoale there, he ordered the depth to be ſounded, and found it to exceed 30 fathoms; and after he had paſſed on a very little farther, he found the Sea ſo deep, that he could not fathom it with his ordinary Line.

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The Second SECTION.

ANother thing obſerv'd at the Bottom of the Sea, is the great preſſure of the water there againſt other Bodies. For what ever men may Philoſophize in their ſtudies, and may conclude from the Principles that are generally received about the *Non-gravitation* of Water in its proper place, yet experience ſeems very little to favour that Generall Doctrine.

For firſt, I remember that having caus'd a pretty large Cylinder of Glaſs, that was open only at one end, to be ſo depreſs'd into a large Glaſs veſſell full of water with a conveniently applyed weight of Lead, that none of the air could get out, I could eaſily diſcern through the Liquor and Veſſells, which were all tranſpirent, that as the inverted Cylinder deſcended deeper and deeper, the externall Water compreſs'd the impriſon'd air, and aſcended higher and higher in the Cavity of the Cylinder, againſt whoſe ſide we had before hand plac'd a row of Marks, whereby to take notice of the graduall aſcent and deſcent of the Internall Water.

Secondly having inquired of two ſeverall obſerving Perſons, whereof one had with a Diving Engin viſited the bottom of the Sea in a Cold Northern Region; and the other had done the like in an Engin much of the ſame ſort, upon the coaſt of Africk, I found their Relations to agree

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in this, that the deeper they deſcended into the Sea, the more the air they carried down with them was compaſſed, and the higher the Water aſcended above the Lip, or Brim of the Engin into the Cavity of it.

But I ſhall now add a more conſiderable experiment or two, to the ſame purpoſe. For diſcourſing one day with an Engineer of my Acquaintance, that had been often at Sea, and loved to try Concluſions, of a way I had thought of, to make ſome eſtimate of the preſſure of the water at a conſiderable depth beneath the ſurface, and ſhew that the preſſure is great there, he told me he could ſave me the labour of ſome Tryalls, by thoſe he had made already, and aſſured me that having divers times opportunity to ſail near the Straights Mouth, over a place where the Sea was obſerved to be of a notable depth, he had found, that if he had let down with a weight into the Sea, not a ſtrong round Glaſs-bottle, but a Violl, ſuch as the Seamen uſe to carry their Brandy and ſtrong waters in, ſuch a Veſſell which might contain a Pint or a Quart of water, would when it came to be ſunk 40 fathom under water, if not ſooner, be ſo oppreſs'd, by the Preſſure of the incumbent, and laterall Water, as to be thereby broken to pieces.

He alſo averred to me, that having exactly cloſed an *Æolipille* of Metall, and with a competent weight, ſunk it to a great depth in the Sea, as to forty, fifty, or ſixty fathom deep, when he pulled

pull'd it up again, he found to his wonder; that the great preſſure of the water, had in divers places cruſht it inwards. And though I had ſome ſuſpition, that the coldneſs of the Sea at ſuch a depth, might by weakning the ſpring of the included Air, ſomething contribute to the effect, yet I did not admire the event, having divers years before had a thin *Æolipile* of Copper cruſht inwards by the preſſure of a much lighter Fluid then Sea-water.

The Third SECTION.

ANother thing observed in the Bottom of the Sea is, the Tranquillity of the VVater there, if it be considerably distant from the surface. For though the VVinds have power to produce vast waves in that upper part of the *Sea* that is expos'd to their violence, yet the vehement agitation diminishes by degrees, as the Parts of the *Sea*, by being deeper and deeper, lye more and more remote from the superficies of the water. So that the Calm being less and less disturb'd towards the Bottom of the water, if that lye considerably deep, the water is there either calm, or scarce sensibly disturb'd.

But that is for the most part to be understood, of places at some distance from the shore; for oftentimes in those that are too near it, the progress of the waters being rudely checkt, and other circumstances concurring, the Commotion of the water is so great, that it reaches to the very bottom, as may appear by the heaps of *Sand*, the Amber, and in some places, the stones that are wont to be thrown up by the Sea, in, and after stormes.

The above mentioned Calmness of the *Sea* at the Bottom (will I doubt not) appear strange to many, who admiring the force of stormy Winds, and the vastness of the VVaves they raise, do not at the same time, consider the almost incompara-

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bly greater Quantity, and weight of VVater that must be mov'd, to make any great commotion at the bottom of the Sea, upon which so great a Mass of Salt-water, which is heavier then fresh, is constantly incumbent. VVherefore for the Proof of the propos'd Paradox, I will here set down a memorable Relation, which my inquiries got me from the Diver elsewhere mentioned, who by the help of an Engin could stay some hours under VVater.

This Person then being ask'd, whether he observed any operation of the VVinds at the bottom of the Sea, where it was of any considerable depth? Answered me to this purpose, That the VVind being stiffe, so that the waves were manifestly six or seven foot high above the surface of the VVater, he found no signe of it at 15 fathom deep; but if the Blasts continued long, then it mov'd the Mudd at the Bottom, and made the water thick and dark. And I remember he told me, which was the Circumstance I chiefly design'd, that staying once at the bottom of the Sea very long, where it was considerably deep, he was amaz'd at his return to the upper parts of the water, to find a Storm there which he dreamt not of; and which was raised in his absence, having taken no notice of it below, and having left the Sea calm enough when he descended into it.

For farther Confirmation, I shall add, that having inquired of a great Traveller, who had assisted at a rich Pearl-fishing in East Indies, whe-

ther he had not learnt by his Converſation with the Divers, that ſtorms reach not to the bottom of the *Sea*, if it be of any conſiderable depth, he anſwer'd, that he had ſeen the Divers take the Water, when the Sea was ſo very rough, that ſcarce any Veſſells, would hazard themſelves out of Ports, that thoſe returning Divers told him, that at the Bottom, they had found no diſturbance of the Water at all. Which is the more conſiderable, becauſe of the ſcituation of that place where they dive for Pearls; for this is near the ſhore of *Manar*, and that it ſelf is ſealed between the great Iland of *Ceylon*, and the vaſt Cape of *Comori*: and though it may be much nearer the former, is not yet far diſtant from the latter. Which ſcituation and the Neighbourhood of the vaſt Indian Ocean, on the one ſide of *Ceylon*, and the great Gulfe of *Bengala*, (anciently *Sinus Gangeticus*) on the other, makes the place where the Pearls are fiſhed for, exceeding likely to be ſubject to very troubled *Seas*.

It will perhaps be thought no ſlight addition to the fore-going Arguments, if I here add, that meeting one day with an ancient and expert *Sea*-man, whom his merit had advanc'd to conſiderable Employments in his Profeſſion, I was confirm'd by the Inquiries I made of him, not only in the Opinion I had about the Calmneſs of the Bottom of the *Sea*, but alſo that the operation of good Gales of VVind, does oftentimes not reach to near ſo conſiderable depths into the *Sea*,

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as hath been hitherto ſuppoſed, even by Navigators themſelves. For he aſſured mee, that having ſometimes ſailed in great Ships that drew much water, as about 12 or 15 foot, he had Div'd to the Keel of the ſhipps, when they are under Sail, and obſerv'd the Agitations of the Water, to be exceedingly diminiſh'd, and grown very languid, even at that ſmall diſtance, from the upper part of the Waves. And he farther anſwered, that when in *America* he learned to Dive of the Indians, they taught him by their Examples, to creep along by the Rocks and great ſtones, that lay near the ſhore at the Bottom of the Water, to ſhelter themſelves from the ſtrokes, and other ill effects of the Billows, which near the ſhore, and where the Sea was ſo ſhallow, as it was there, did often hurt and endanger Swimmers and unskillfull Divers. But when they were by this means got further from Shore and into deeper VVater, they would ſecurely leave the ſhelter they had till then made uſe of, and ſwim within a few yards of the Surface of the Sea, as fearing there no danger from the Toſſings and Commotions of the upper parts of the Water.

But laſtly, for further ſatisfaction, I had the opportunity to make inquiry about this matter of a great Sea Commander who has both an extraordinary curioſity to make marine Obſervations, & an unuſuall Care in making of them accurately, I found the Opinion countenanced by his Anſwer, which was in ſhort; That he had lately

been at a place where the *Sea* was often tempestuous enough, and that they found by a sure mark that the Storm did not reach with any efficacy four fathom beneath the *Surface* of the Water.

About the Tranquillity of the Lower Parts of very deep waters I had a suspition, which though I fear it might seem somewhat extravagant, because I have not met with it in Authors; yet I thought it worth examining for the use it might be of, if resolv'd in reference to the Ebbing and Flowing of the *Sea*.

I made therefore a *Solicitous* Inquiry whether the Tides did reach to, or near the Bottom of the deeper Seas, but found it exceeding difficult by reason of mens want of Curiosity to obtain any satisfaction about a Problem that most Navigators I have conversed with did not seem to have so much as dreamd of. But thus much I found indeed by inquiring of an *Engineer* who was curious of Marine Observations, that a famous *Sea* Commander of his Acquaintance being also a great Mathematician, had affirmed to this Relator, that he had divers times observ'd, that when he let down his Plummet to a great depth but yet not to reach ground, it would be quickly carried by a motion quite cõtrary to that of the *Shallop* whence they sounded and very much quicker then it; but I had this only at second hand. Also, if I mis-remember not, I was informed by a skillful Observer that commanded many of our English men

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of Warr, that he had near the ſound obſerved the upper and Lower parts of the VVater to move with a conſiderable ſwiftneſs quite different wais; but not having committed this Relation to writing, I dare not build much upon it. And among the Anſwers I had received and written down concerning thoſe matters, all that I can yet find among my Adverſaria, is a Relation which though ſingle, will not be unworthy to be tranſcrib'd in this Place, becauſe the Perſon who gave it me, is one of the ancientſt and moſt experien'ſt Pilots of our Nation.

This Perſon therefore aſſured me, that ſayling beyond the *Cape of Good Hope* into the South *Seas*, made Tryalls of the motion of the upper part of the Water above the lower, where ſometimes caſting out a large and heavy Plummet, he let it down to ſeverall depths ſhort of 50 fathom, without any ſenſible Operation upon the motion of the Boat, or Shallop he ſtood in to make the Tryall; but when he let down the Plummet lower, to about an hundred fathom or more, then he found that though the Plummet reached not to the Bottom of the Water, yet upon the ſcore of the ſtanding water beneath, the Superiot VVater would make the Boat turn towards the Tide or Current, as if it lay at Anchor, and the water would run by the ſide of the Boat at the rate of about three mile an hour, Thus far this diligent Obſerver. But how far the inequality of the Soil at the bottom of the *Sea*, and how far the various

various depth of the VVater, and some other circumstances, may alter the case, and make it hard to determine, what ought to be ascribed to Tides and what to Currents, and are things which I will by no means be positive in, till I can meet with further Information.

[*Since* the writing of this, hapning to meet with one that spent some time at a famous Easterne Pearle-fishing, and asked him whether he had inquired of the Divers about the Problem lately proposed, and whether the Sea were there deep enough to make observations of that kind: To the latter part of which Question he replyed, that in some places it was of a very considerable depth, and fit to make the observation in; And to the former he answered, That he had inquired of the Divers, who affirmed to him that sometimes at the Bottom of the Deep waters there seem'd to be a stagnation of the *Sea* for a great depth, so that till such a height they could rise directly upwards, but that at other heights they would be carried away by the lesse deep-waters; so as to be found when they came to emerge a great way off from that point of the surface which was perpendicular to that place at the Bottom, whence they began to ascend.]

FINIS.